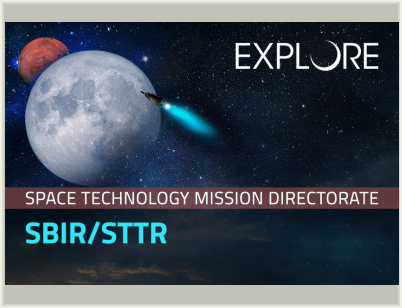
A Refined Model for the Behavior of Nitrous Oxide to Assess the Limits of N2O Cooling, Phase I

Completed Technology Project (2011 - 2012)

Project Introduction

The proposed project is crucial to enabling safe flight research on a rocket nozzle that is based on our recent innovation, which is to use the refrigerant capabilities of nitrous oxide (N2O) to provide cooling for an aerospike nozzle on hybrid rocket motor using N2O as the oxidizer. The phase change cooling as liquid N2O is flashed from a liquid into a vapor, limits to acceptable levels the erosion of both the nozzle throat and spike, thereby enabling reusable operation and/or long burn times. The N2O used for cooling will be reintroduced into the rocket motor and used to boost performance. Because of potentially the violent exothermic decomposition of N2O, a thorough understanding of N2O behavior is crucial to developing an aerospike nozzle and hybrid rocket motor that are sufficiently safe for flight testing, where cooling the aerospike is necessary to get the burn duration required for good flight tests to yield the illusive flight test data for aerospike nozzles. Our prior work seeking to develop a fundamental understanding of the behavior of N2O when it is used in applications has answered some important questions about the behavior of N2O, yielded significant advances in designing instrumented nozzles for N2O cooling experiments, and generated important advances in making accurate temperature measurements on the coolant flowing in these nozzles. However, our work in developing and validating analytical models for predicting heat transfer coefficients in N2O-cooling applications was only partially successful due to unanticipated levels of uncertainty from a variety of sources. By addressing the sources of the above-mentioned uncertainty using a combination of nozzle design, novel construction, analytical, FEA, and CFD modeling, along with experimental validation of all models, this work will yield the refined models of N2O behavior that are necessary for the future design of safe N2O-cooled aerospike nozzles.



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Small Business Innovation Research/Small Business Tech Transfer

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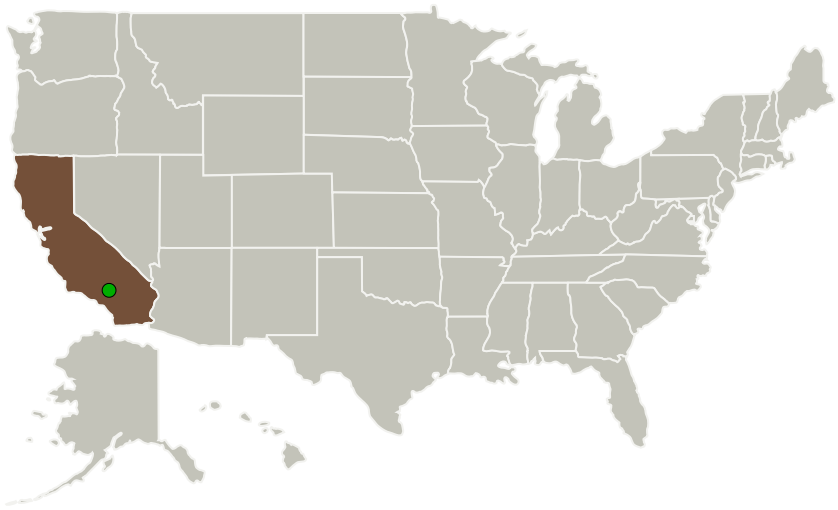
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Rolling Hills Research Corporation	Lead Organization	Industry	El Segundo, California
Armstrong Flight Research Center(AFRC)	Supporting Organization	NASA Center	Edwards, California
California Polytechnic State University-San Luis Obispo(Cal Poly)	Supporting Organization	Academia	San Luis Obispo, California

Primary U.S. Work Locations
California

Project Transitions

February 2011: Project Start

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

Rolling Hills Research Corporation

Responsible Program:

Small Business Innovation Research/Small Business Tech Transfer

Project Management

Program Director:

Jason L Kessler

Program Manager:

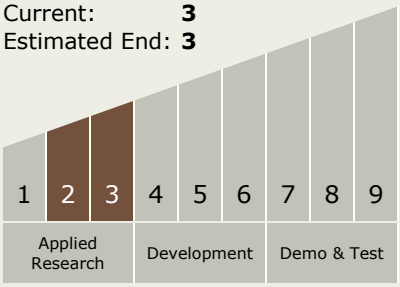
Carlos Torrez

Principal Investigator:

William Murray

Technology Maturity (TRL)

Start: **2**
Current: **3**
Estimated End: **3**



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February 2012: Closed out

Closeout Documentation:

- Final Summary Chart*(https://techport.nasa.gov/file/137922)*

Technology Areas

Primary:

- TX01 Propulsion Systems
  - TX01.1 Chemical Space Propulsion
    - TX01.1.5 Hybrids

Target Destinations

The Sun, Earth, The Moon, Mars, Others Inside the Solar System, Outside the Solar System